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(54) Minimizing power consumption in e.g. portable computing devices

(57) To minimize power consumption in a computing device, which executes requested tasks in a high power mode, in which it has normal processing power and, correspondingly, normal power consumption, and is then switched to a low power mode, in which it has limited processing power and, correspondingly, a considerably lower power consumption, the power consumption is decreased by lengthening the time during which the device remains in the low power mode in such a way that the device is not switched to a high power mode immediately when the user starts the input, but the switching is delayed. The switching to the high power mode can be done on the basis of a sign included in the input, after a certain time (set or programmable) has passed since the input began, when a specified time has passed since the input stopped, or when a certain amount of information has been received after the input began. The means for the user input may preferably comprise a touch screen and a pen means.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

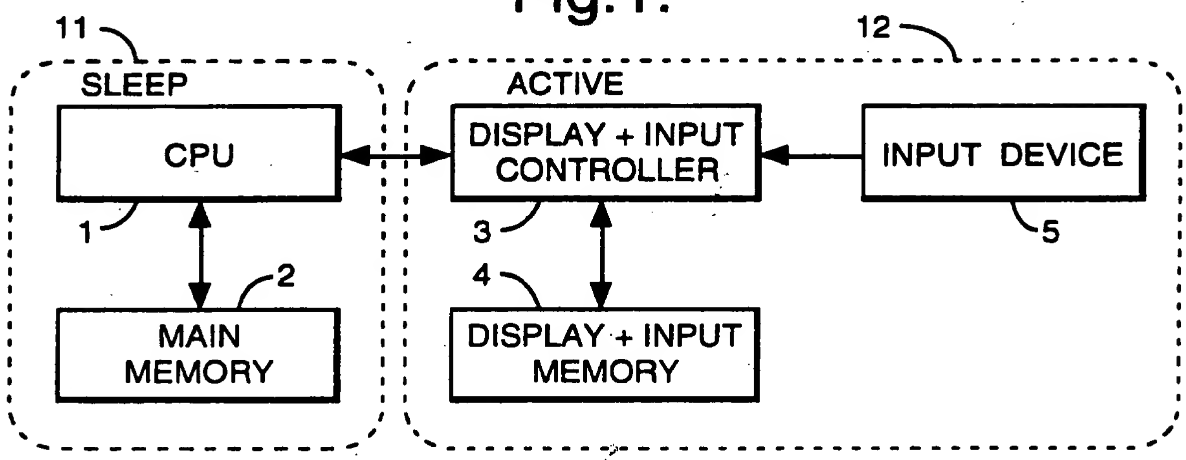

11
12
SLEEP
ACTIVE
CPU
DISPLAY + INPUT CONTROLLER
INPUT DEVICE
1
3
5
2
4
MAIN MEMORY
DISPLAY + INPUT MEMORY

Fig.2.

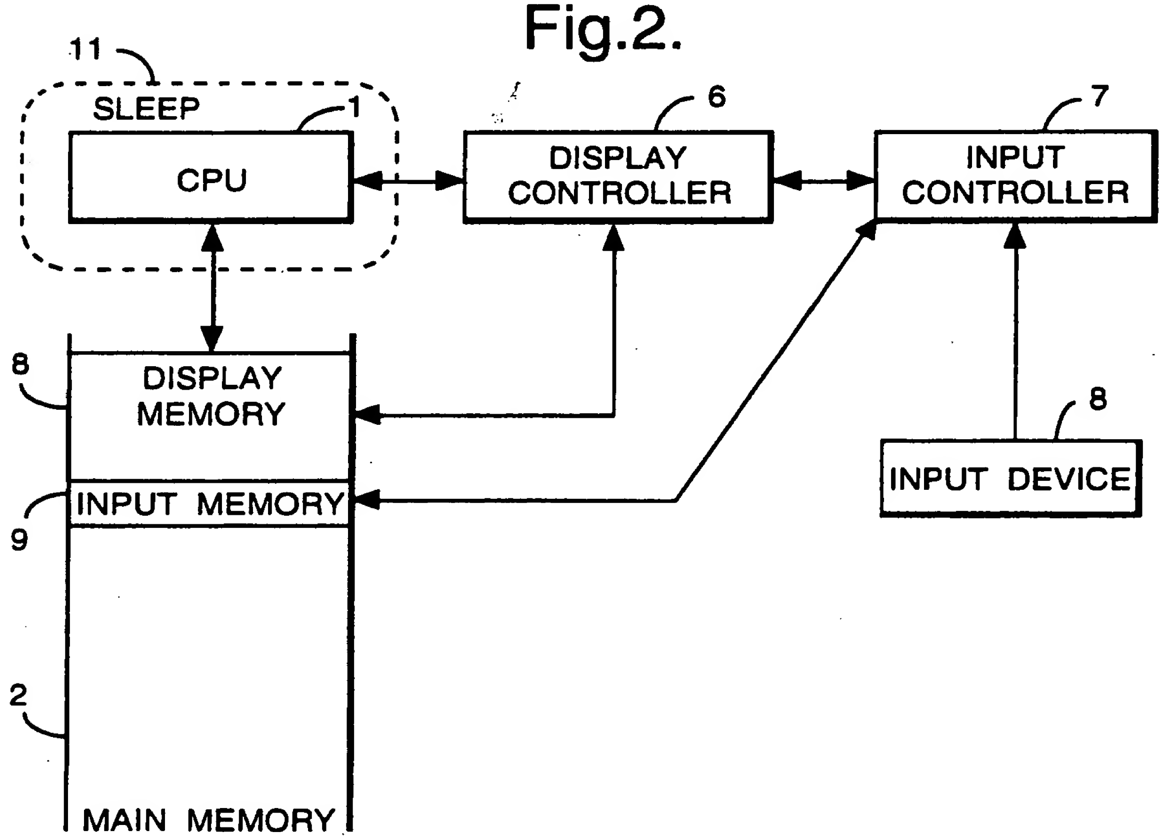

11
SLEEP
1
6
7
CPU
DISPLAY CONTROLLER
INPUT CONTROLLER
8
DISPLAY MEMORY
INPUT MEMORY
9
8
INPUT DEVICE
2
MAIN MEMORY

Fig.3.

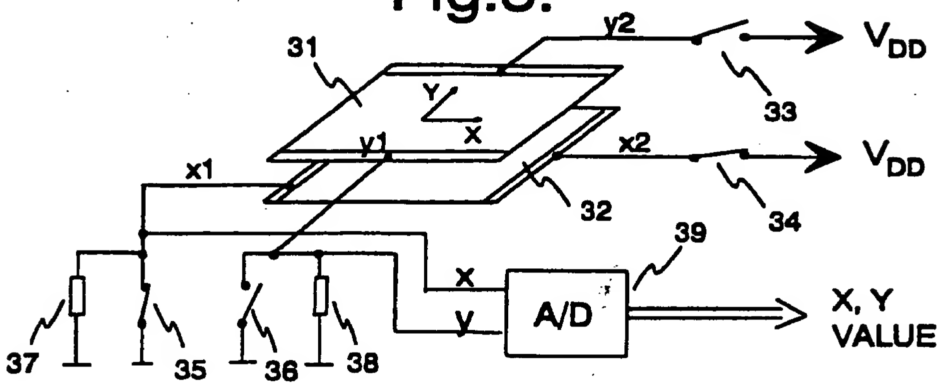


Fig.4.

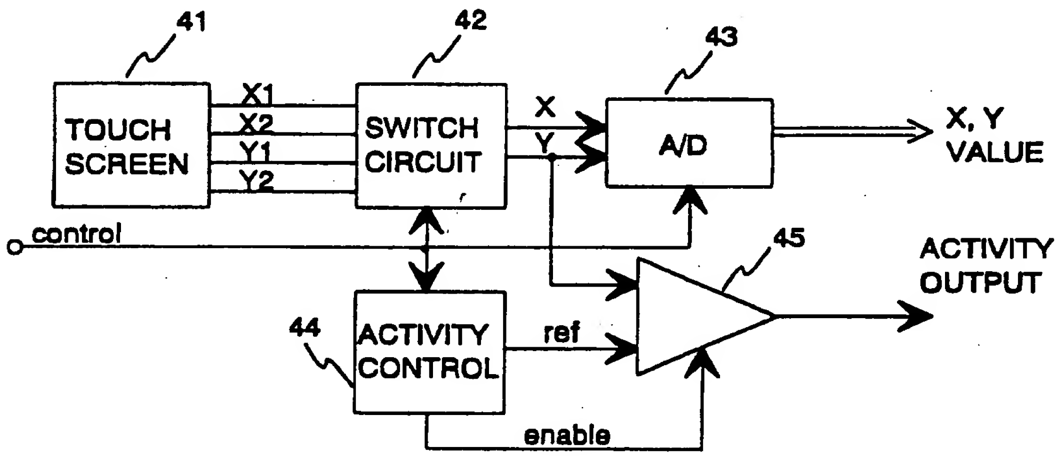
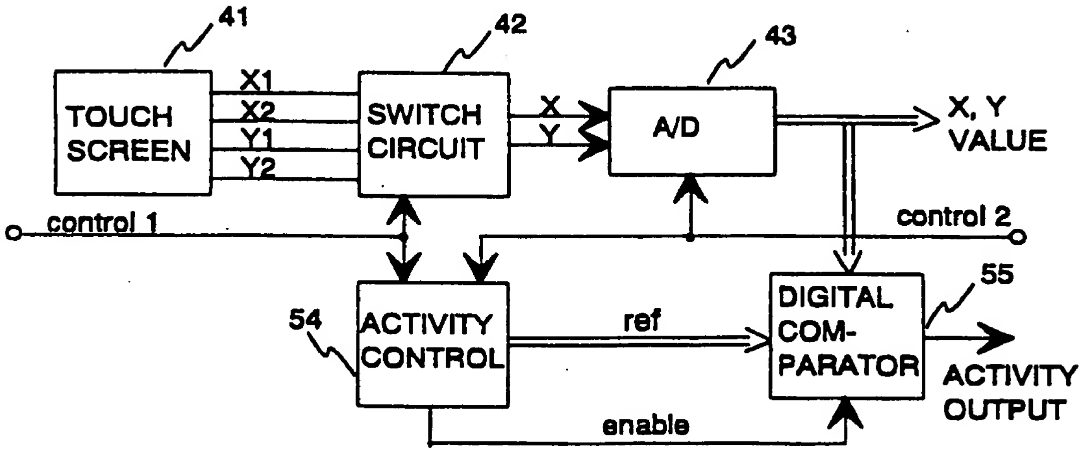


Fig.5.



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ELECTRONIC EQUIPMENT

This invention relates to lowering power consumption in computing devices, which can be set at a so-called low power mode in addition to a normal mode wherein the power consumption is high. In the low power mode the power consumption is considerably less, but the processing power is also limited.

The invention is particularly applied to portable computing devices, in which power is not supplied by a main power supply, but by batteries as either a primary or secondary power supply, or, for example, solar cells. The current portable computing devices typically have a display, an input arrangement based on use of a pen type input device in connection with the display, and means for recognizing handwritten input by the user. The so-called PDA computers (PDA, Personal Digital Assistant) or various kinds of computing devices including radio telephones that communicate via a mobile communications network, for example, GSM, are examples of the type of computing devices mentioned above.

In a low power mode, unused parts of a portable computing device are switched off or set at a specific low power state. The low power mode can be implemented, for example, by decreasing the clock frequency of the processor. If the normal clock frequency is, for example, 33 MHz, the low power mode it can be, for example, 1 MHz. On the other hand, if the computing device has a separate input controller that has processor capacity of its own, for example, a so-called micro controller, this separate input controller can be kept active in the low power mode, and the actual processor can be set to a sleep mode. When the user of a pen based computing device is not doing anything with the device, the device can be set at low power mode, in which only the display is refreshed, and the device is ready to receive input entered by using a pen

device and the display. The processing power of a computing device is low in the low power mode, and only a few functions can be performed, whereas, in the normal mode, which is referred to as a high power mode in this application, the device has full processing power.

A known method for decreasing the power consumption of a computing device is to set the device at a low power mode to await user input after it has executed the given tasks in the high power mode. When the user begins to enter new input, the computing device immediately switches to the high power mode, and after executing the given tasks returns to the low power mode, and so on.

In order to achieve this object, the characteristics of the invention's method for minimizing the power consumption of a computing device are those, which have been presented in claim 1.

This provides the advantage of a further decrease the power consumption of a portable computing device by increasing, in comparison with the known method, the time, in which the device remains in the low power mode.

The invention is based on the idea that the operation of a computing device can be arranged in such a way, that it is not necessary for the device to immediately switch to a high power mode when the user starts entering input. Instead, the device can receive some amount of input in the low power mode, and switch to the high power mode on the basis of some criteria, without any reduction in the operation or total processing power.

In methods in accordance with the invention, a computing device executes the given tasks in the high power mode, in which it has normal processing power and, correspondingly, normal power consumption, and after it has executed the

given tasks, it is set at the low power mode, in which it has limited processing power and, correspondingly, considerably lower power consumption than normally. The computing device includes, for execution of the given tasks, the processor means, memory means, display means and corresponding control means, and input means and corresponding control means. The computing device includes means to indicate the beginning of input in the low power mode and the invention's method for minimizing the power consumption of a computing device is characterized in that one or several criteria are set to control the switching of the device to the high power mode after the beginning of input has been indicated, and that after the beginning of input has been indicated, the device is retained in the low power mode while the fulfilling of one or several criteria that have been set is monitored, and that the device is set at the high power mode when one or several criteria that have been set are fulfilled.

A computing device can be further implemented in such a way that it is able to receive and recognize input information in the low power mode, and that the criteria for switching to the high power mode is a sign included in the input after obtaining of which sign the device switches to the high power mode. The sign is primarily a simple one, in order for the device to recognize it without using high processing power. It can be, for example, in a pen based portable computer, a sign that is added to the input information when a certain part of the display is touched with the pen or when a specific simple stroke of the pen is drawn on the display. In a computing device that can receive and recognize speech input, the sign can be a corresponding sign that is added to the input information when a simple spoken sign is uttered.

In a simple implementation of the method of the invention, a time period, which is counted from the beginning of the user input, is set. After the given time has

passed since the beginning of the input, the device switches to the high power mode. The time to be set can be programmable.

Another possibility is to use the length of a break in the user input as the criteria. In this case, the idea is that the user has entered the required input and waits for the computing device to switch to the high power mode. The length of the break can also be programmable.

Yet another possible criteria is the amount of information that has been entered after the beginning of the input. This can also be programmable.

A computing device can be implemented in such a way that, from the above-mentioned criteria, several alternative criteria are set or some combination of criteria is used.

Implementation of the method of the invention in a computing device is described in more detail in the following. References are made to the figures, of which:

Figure 1 shows, as a block diagram, an implementation of a computing device, in which the method of the invention can be used, and

Figure 2 shows, as a block diagram, another implementation of a computing device, in which the method of the invention can be used.

Figure 3 shows a circuit diagram of a touch screen for receiving input information.

Figure 4 shows an analog implementation of a touch screen for a computing device, in which the method of the invention can be used.

Figure 5 shows a digital implementation of a touch screen for a computing device, in which the method of the invention can be used.

In figures 1 and 2, only those blocks of the computing device, that are necessary for describing the invention, are presented. CPU 1 is the main processor of the device. It processes the applications used in the device and usually also handles, for example, the speech recognition. A special processor, for example, a digital signal processor, can also be used for this purpose, but this alternative has not been presented in the figures. The main memory 2 contains primarily the programs and application data, but it can also have special memory areas, such as display memory 8 and input memory 9 as presented in figure 2. Another possibility is that there is a special memory for the display and input data, as presented in block 4 of figure 1. The display memory is used to store the current display data, and the input memory to store the input information. Additionally, computing devices have a display controller, which takes care of refreshing the display and controlling the display and the display memory, and an input controller, which controls the input and the input memory and processes the input information, if necessary. In the implementation in figure 1, the display controller and the input controller are presented as one in block 3, and in the implementation in figure 2 as separate in blocks 6 and 7. Additionally, in the block diagrams of figures 1 and 2, the input means 5 have been presented. In this description, the input means is primarily a pen type input device, which is used together with the display 10. On the other hand, the input means can include a normal keyboard or, for example, a speech input device in a computing device, which can receive speech input.

In the implementation in figure 1, the blocks are divided into two areas, 11 and 12, which are marked with a broken line in the figure. The blocks belonging to area 11, the CPU 1 and the main memory 2, can be switched to a low power mode without interfering with the display. The display/input controller 3 controls the display/input memory 4. The CPU has access to the display memory either via the display/input controller 3 or directly with the help of DMA (not presented in the figure). The display/input controller can be either tightly or loosely coupled. The input means 5 and the display 10 are connected, so that, the user input can also be seen on the display. The display can be an LCD display, and the input can be entered by use of a resistive touch produced by a pen type device. The display/input controller 3 controls the touch input and calculates the locations of the user inputs.

In the implementation in figure 2, only the CPU 1, which is marked with a broken line as area 11, can be switched to a lower power mode. Because the display and input memories 8 and 9 are special areas of the main memory, there must be access to the main memory in order to refresh the display and store the required amount of information in the low power mode. The display controller 6 and the input controller 7 can access the corresponding memory areas directly with the help of DMA. Additionally, the input controller 7 may access the display memory area 8 via the display controller 6 or directly with the help of DMA. The display controller and the input controller can be tightly or loosely coupled.

The method of the invention is implemented primarily in connection with the input controller. If the input controller uses the processing capacity of the CPU, the low power mode can be implemented by decreasing the clock frequency, as was described earlier. In this case, the CPU works, but its processing power is considerably less than in a normal high power mode. If the input controller is a separate micro controller, it has full processing power in the low power mode,

whereas, the CPU is primarily in a sleep mode. It is clear for a person skilled in the art, that if the criteria for a switch to a high power mode, after the beginning of input has been indicated, is a time period that has passed since the beginning of the input or the length of a break in input, the fulfilling of the criteria can be monitored in a very simple way, which does not necessarily need processing capacity. If the time criteria is implemented as programmable, the easiest solution is to use the processing capacity available in a low power mode. The situation is the same when the criteria are based on the amount of input or especially when the criteria are based on the recognition of an entered sign. When the input controller decides in the low power mode, by using the available processing capacity, that the criteria have been fulfilled, the device can be switched to a high power mode, for example, in the way that the input controller creates an interrupt for the CPU.

Figure 3 shows a circuit diagram of a touch screen that can be used for information input in implementing the method according to the invention. The touch screen comprises two resistive films 31 and 32 which have measuring conductors x1, x2, y1 and y2. The measuring conductors are connected to the edges of the films in such a way that a voltage between the measuring conductors y1 and y2 causes a current in the Y-coordinate direction in the film 31. A voltage between the measuring conductors x1 and x2 causes a current in the X-coordinate direction in the resistive film 32.

The two films are separated when the touch screen is not touched. When the touch screen is touched with a pen, the resistive films are connected in the point where the pen touches the screen. The position of the touching point can be measured with the measuring conductors that are attached to the films by measuring the X- and Y-coordinates of the touching point in the following manner. A voltage VDD is connected to the second measuring conductor x2 of the film 32 by closing the switch 34. The first measuring conductor x1 is

connected to the zero potential by closing another switch 35. The voltage that is applied to the film 32 causes a current in the direction of the X-coordinate in the film 32. The voltage in a certain point of the film is thus directly proportional to the position in the X-coordinate. The first measuring conductor y1 of the first foil is connected to the input of the analog/digital-converter or A/D-converter 39. When the touch screen is touched with a pen, the first film 31 touches the second film 32, and the voltage in the touching point of the second film 32 is connected to the first film 31 and via the measuring conductor y1 the voltage is further led to the input of the A/D-converter. The output value of the A/D-converter is thus directly proportional to the X-coordinate position of the touching point. When the X-coordinate is measured, switches 33 and 36 are open.

Correspondingly the Y-coordinate position of the touching point is measured by setting the switches 34 and 35 open and setting the switches 33 and 36 closed. The voltage VDD then causes a current in the direction of the Y-coordinate in the foil 31. The voltage in the touching point is connected to the second film 32, and is measured with the A/D-converter 39. The A/D-converter has separate inputs for x- and y-signals. By controlling the switches 53, 54, 55 and 56 it is possible to measure X- and Y-coordinate values sequentially and to measure the changes of the position as the pen moves on the surface of the touch screen.

Resistors 37 and 38 have high resistance value and they are connected from the measuring conductors x1 and y1 to the zero potential. The purpose of the resistor is to connect the film to the zero potential when the switch that is parallel to the resistor is open and when the touch screen is not touched. This way the input of the A/D-converter is in the zero potential when the film is not touched, and the input of the A/D-converter is in the voltage that corresponds to the coordinate of the touching point when the touch screen is touched with

a pen. If the touch surface of the touch screen is slightly smaller than the area of the film, then even touching the edges of the touch screen gives a non-zero voltage to the A/D-converter. Then by measuring the voltage of the film it is possible monitor whether the touch screen is touched or not. This monitoring can be made by measuring one of the two coordinate signals. In the idle state this monitoring can be made from one signal and when a touch is detected, measuring of both touch point coordinates can be started. The signal of the first touch can further be used for controlling the computing device to the high power mode.

Figure 4 shows an implementation where a touch screen is used for setting the computing device to the high power mode. The measuring conductors x1, x2, y1 and y2 of the touch screen 41 are led to the switch circuit 42, which gives the X- and Y-coordinate signals to the A/D-converter 43. The switch circuit and the A/D-converter are controlled by the processor (not shown in figure 4) in such a way that in the active mode of the touch screen the X- and Y-coordinates are measured sequentially. In the idle mode of the touch screen the signals are not measured by the A/D-converter 43 but one of the signals is measured by an analog comparator 45. The comparator 45 compares the signal to a reference signal that is received from an activity control unit 44. When the level of the measured signal exceeds the reference signal level, the activity output of the comparator changes to the active state and thus informs the processor that the touch of the touch screen has been detected. After receiving this information the processor begins to measure the X- and Y-coordinates by controlling the switch circuit and the A/D-converter with a control signal. The control signal is also led to the activity control unit, which disables the output of the comparator with an enable signal when the touch screen is in the active mode.

Figure 5 shows an implementation which has a similar touch screen 41, switch circuit 42 and A/D-converter 43 as the implementation in figure 4, but where a digital comparator 55 is used. In the idle mode of the touch screen the comparator measures the digital output of the A/D-converter 43 and compares it with the digital reference value that is received from the activity control unit 54. When the measured value exceeds the reference value, the activity output signal of the comparator informs the processor that a touch to the touch screen has been detected. After this the processor controls the switch circuit and A/D-converter with control signal 1 and control signal 2 in such a way that it receives X- and Y-coordinate values sequentially from the A/D-converter. In this active mode of the touch screen the activity control unit 54 disables the activity of the comparator 55 until the processor stops reading the coordinate values.

The implementation in figure 4 has a benefit that the A/D-converter can be in idle mode when the touch screen is in the idle mode. If a digital comparator is used, as in figure 5, the A/D-converter must perform conversions also in the idle state of the touch screen, and this is why the switch circuit 42 and the A/D-converter 43 are controlled with separate control signals. In this implementation with digital comparator energy can be saved by controlling the A/D-converter with a much lower frequency in the idle state of the touch screen than in the active state. The relation between the sample frequencies of the active and idle modes can be 1:10, for example.

Touch screen can be used for setting the computing device to high power mode in two ways: the touch screen may give an indication that the user input has started and the touch screen can be used for entering the sign for setting the computing device to the high power mode. In order to receive input, the touch screen normally turns into active mode before the computing device turns into high power mode.

The present invention includes any novel feature or combination of features disclosed herein either explicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems addressed.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS

1. An electronic device operable to execute one or more of a set of functions in a high power mode, the electronic device being operable to enter the high power mode from a lower power mode in response to an indication that execution of one of the set of functions is requested, operation in the high power mode being delayed until a predetermined condition has been fulfilled.

2. An electronic device as claimed in claim 1 wherein the electronic device enters a power mode intermediate the low and high power modes in response to an indication that execution of one of the set of functions is requested for making a determination that the predetermined condition is fulfilled.

3. An electronic device as claimed in claim 1 or claim 2 wherein the predetermined condition is expiry of a predetermined period from the indication that execution of one of the set of functions is requested.

4. An electronic device as claimed in claim 1 or claim 2 wherein the predetermined condition is user input of a predetermined signal.

5. An electronic device as claimed in claim 4 wherein the electronic device comprises a touch sensitive screen and the predetermined signal comprises touching a predetermined area of the touch sensitive screen.

6. A method for minimizing power consumption in a computing device, which comprises, for executing the requested tasks, processor means (1), memory means (2, 4, 8, 9), display means (10) and corresponding control means (3, 6), and input means (5) and corresponding control means (3, 7), which executes the requested tasks in a high power mode, in which it has

normal processing power and, correspondingly, normal power consumption, and which, after it has executed the requested tasks, is switched to a low power mode, in which it has limited processing power and, correspondingly, a considerably lower power consumption, the means (1-9) for the execution of the requested tasks comprising means for indicating the input in the low power mode, wherein at least one criterion is set in the computing device for switching of the device to the high power mode after it has been indicated that input has begun,after the beginning of the input has been indicated, the device is retained in the low power mode and the fulfilling of the criterion/criteria that have been set is monitored, the computing device is switched to the high power mode when the criterion/criteria that have been set are fulfilled.

7. A method in accordance with claim 6, in which the means (1-9) for the execution of the requested tasks include devices for receiving and recognizing input in the low power mode, wherein the said criteria for switching the computing device to the high power mode include the recognition of a sign that is included in the input.

8. A method in accordance with claim 7, in which the input means (5, 8) include a pen means, which is used in connection with the display means, wherein the sign included in the input is produced by touching a certain area of the display means with the pen means.

9. A method in accordance with claim 7, in which the input means (5, 8) include a pen means, which is used in connection with the display means, wherein the sign included in the input is a specific stroke drawn on the display means by using the pen means.

10. A method in accordance with claim 2, in which the input contains a speech input, wherein the sign included in the input is a spoken sign.

11. A method in accordance with claim 6, wherein the criteria for switching the computing device to the high power mode include elapsing of the preset time calculated from beginning of the input.

12. A method in accordance with claim 11, wherein the preset time is programmable.

13. A method in accordance with claim 6, wherein the criteria for switching the computing device to the high power mode include occurring of a break of a specific length of time in the input after the input has begun.

14. A method in accordance with claim 8, wherein the length of the break is programmable.

15. A method in accordance with claim 6, in which the means (1-9) for the execution of the requested tasks include devices for receiving and recognizing input in a low power mode, wherein the criteria for switching the computing device to the high power mode include a certain amount of input received after the input has begun.

16. A method in accordance with claim 15, wherein the amount of input is programmable.

17. A method in accordance with claim 6, in which the means (1-9) for the execution of the requested tasks include a pen means, which is used in connection with the display means, which may be a touch screen, wherein the beginning of the input is indicated in the low power mode by detecting a touch of the pen means to the display means.

18. A method in accordance with claim 8,9 or 17 wherein after switching to the low power mode, the first touch of a pen means to the display means is monitored and, after the first touch of the pen means to the display means is detected, the position of the pen means on the display means is monitored.

19. A computing device,
which comprises, for executing the requested tasks, processor means (1), memory means (2, 4, 8, 9), display means (10) and corresponding control means (3, 6), and input means (5) and corresponding control means (3, 7),which executes the requested tasks in a high power mode, in which it has normal processing power and, correspondingly, normal power consumption, and
which, after it has executed the requested tasks, is switched to a low power mode, in which it has limited processing power and, correspondingly, a considerably lower power consumption, the means (1-9) for the execution of the requested tasks comprising means for indicating the input in the low power mode, the computing device being wherein
it has means for setting at least one criterion for switching of the device to the high power mode after indicating the input,
it has means for monitoring the fulfilling of the criterion/criteria that have been set after the input has been indicated, and
it has means for switching the computing device to the high power mode when the criterion/criteria that have been set are fulfilled.

20. A computing device in accordance with claim 14, wherein the input means comprises a touch screen (31, 41) and a pen means for providing an analog signal that is a function of a touch of the pen means to the touch screen.

21 A computing device in accordance with claim 20, comprising an A/D-converter (43) for converting the signal that is received from the touch screen into a digital signal.

22. A computing device in accordance with claim 20 or 21, further comprising means (44, 54) for providing a reference signal and a comparator (45, 55) for comparing the first input signal that is the reference signal to the second input signal thet is received from the touch screen and for giving an output signal that is a function of the difference of the two input signals for indicating the touch of a pen means to the touch screen.

23. A computing device in accordance with claim 22, wherein the comparator (55) is a digital comparator.

24. A computing device in accordance with claim 22 comprising means for measuring the location of the touch of the pen means to the touch screen and these means for measuring are activated by the output signal from the comparator.

25. A computing device in accordance with claim 22 wherein the meansfor monitoring the criterion / criteria for switching the computing device to the high power mode are activated by the output signal from the comparator.

26. An electronic device substantially as hereinbefore described with reference to Figures 1 and 3, 4 or 5, or 2 and 3, 4 or 5.

27. A method substantially as hereinbefore described with reference to Figures 1 and 3, 4 or 5, or 2 and 3, 4 or 5.

Patents Act 1977 17 **Examiner's report to the Comptroller under Section 17 (The Search report)**	Application number GB 9520422.8
Relevant Technical Fields (i) UK Cl (Ed.O) G4A (AKS, AGB) (ii) Int Cl (Ed.6) G06F 1/32	Search Examiner M J DAVIS Date of completion of Search 16 JANUARY 1996
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-27

Categories of documents

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2144889 A	(IBM)	1, 6, 19 at least
X	EP 0553862 A2	(CANON)	1, 6, 19 at least
X	EP 0171747 A2	(METAPHOR) eg pages 22-23 and Figure 1	1, 6, 19 at least

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